HIGH-DENSITY PLASMA SOURCE FOR LARGE-AREA CHEMICAL VAPOR DEPOSITION OF DIAMOND FILMS

Principal Investigator

Dr. Xing Chen

SCIENCE RESEARCH LABORATORY, INC.
15 Ward Street
Somerville, MA 02143
(617) 547-1122

Contract Dates: September 30, 1994 to March 30, 1995

Reporting Period: November 1, 1994 to November 30, 1994

Contract No. N00014-94-C-0199

Prepared for

Scientific Officer
Attn: Max Yoder
Office of Naval Research
Ballston Tower One
800 North Quincy Street
Arlington, VA 22217-5660

December 15, 1994

SCIENCE RESEARCH LABORATORY

HIGH-DENSITY PLASMA SOURCE FOR LARGE-AREA CHEMICAL VAPOR DEPOSITION OF DIAMOND FILMS

MONTHLY REPORT

Overview

During this program Science Research Laboratory (SRL) and the Plasma Processing Group in the Department of Chemical Engineering at MIT are developing a large-area, directed plasma/atomic beam source for diamond deposition. The plasma source is based on an inductively-driven plasma accelerator that efficiently produces a high density (10^{14}-10^{17} cm^{-3}) plasma over an area of 0.1-1 m^2. The goal of this effort is to experimentally demonstrate the technical feasibility of employing the plasma source for high-throughput diamond deposition, through characterization of plasma parameters and preliminary diamond deposition experiments. A reactor design study will also be completed during Phase I, leading to an engineering design of a large-area plasma reactor for Phase II implementation. The period of performance is from 30 September 1994 to 31 March 1995.

November Progress

The preliminary activity during November was construction of the plasma beam reactor and diagnostics. The plasma reactor is based on an inductively-driven, large area plasma accelerator that is funded under a separate electric thruster program. Because of previous funding delay on that program, intensive effort was made to accelerate the construction of the plasma beam source. This plasma source consists of a 100-joule-per-pulse, 1 kilopulses-per-second driver, an inductive plasma acceleration coil, a gas handling system and a vacuum system. The pulsed driver, induction coil and vacuum electric feedthroughs are all currently under fabrication. Assembly and test of the system are scheduled to start from early January.

Major modifications to the experimental system to convert it to a plasma reactor include installation of a heated silicon/molybdenum wafer substrate for diamond deposition, an active cooling unit on the induction coil to allow high average power operation and plasma diagnostics for measuring critical plasma parameters. During November the design of the wafer substrate and a backplate that interfaces the wafer substrate and the plasma accelerator were completed. A first attempt to cast the cooling unit was made but the result was unsatisfactory because of incomplete detachment of the epoxy from the mold. The fabrication of a Rogowski coil, a magnetic probe, and a double Langmuir probe needed for plasma measurement were completed.

The active cooling unit to the induction coil is essential for the plasma reactor to operate at high average power and at extended duration as required by diamond deposition experiments. The unit will be made with a high thermal conductivity epoxy - Insulcast 147 from Permagile Industries – that has a thermal conductivity two times higher than that of typical stainless steel. Figure 1 shows the design of the cooling unit which is to be potted onto the back of the induction coil. Two separate approaches to fabricate this unit is currently underway. A solid piece of the base material without water flowing channel has been casted and cured. Efforts will be made to machine the water flowing channels in this cast material. In addition, fabrication of a polyethelene mold, which was tested to be non-stick to the epoxy, has been ordered. We expect at least one of this fabrication technique will succeed.

After examining the reactor blueprints given by SRL, the MIT group has paid another visit to SRL to discuss the physical and material constraints presented by diamond deposition experiments. The design of the silicon wafer substrate and a backplate to be mounted on the high density plasma chamber was completed. The backplate design has the capability to hold the silicon or molybdenum wafer substrate for diamond deposition while allowing for independent substrate temperature control. Vertical and horizontal displacement of the sample can be achieved. It also provides ports to accommodate optical and electric diagnostics for plasma species concentration measurements. This backplate will be fabricated during December. The design of the Pt/Pt-Rh thermal couple probe and optical diagnostics for H atom and excited species concentration measurements is underway at MIT.

Looking towards the third month in this program, we expect to complete the diagnostic design and fabrication, as well as the fabrication of the induction coil cooling unit. The fabrication of the induction coil and the vacuum system, which are performed under separate funding, are also expected to be completed.

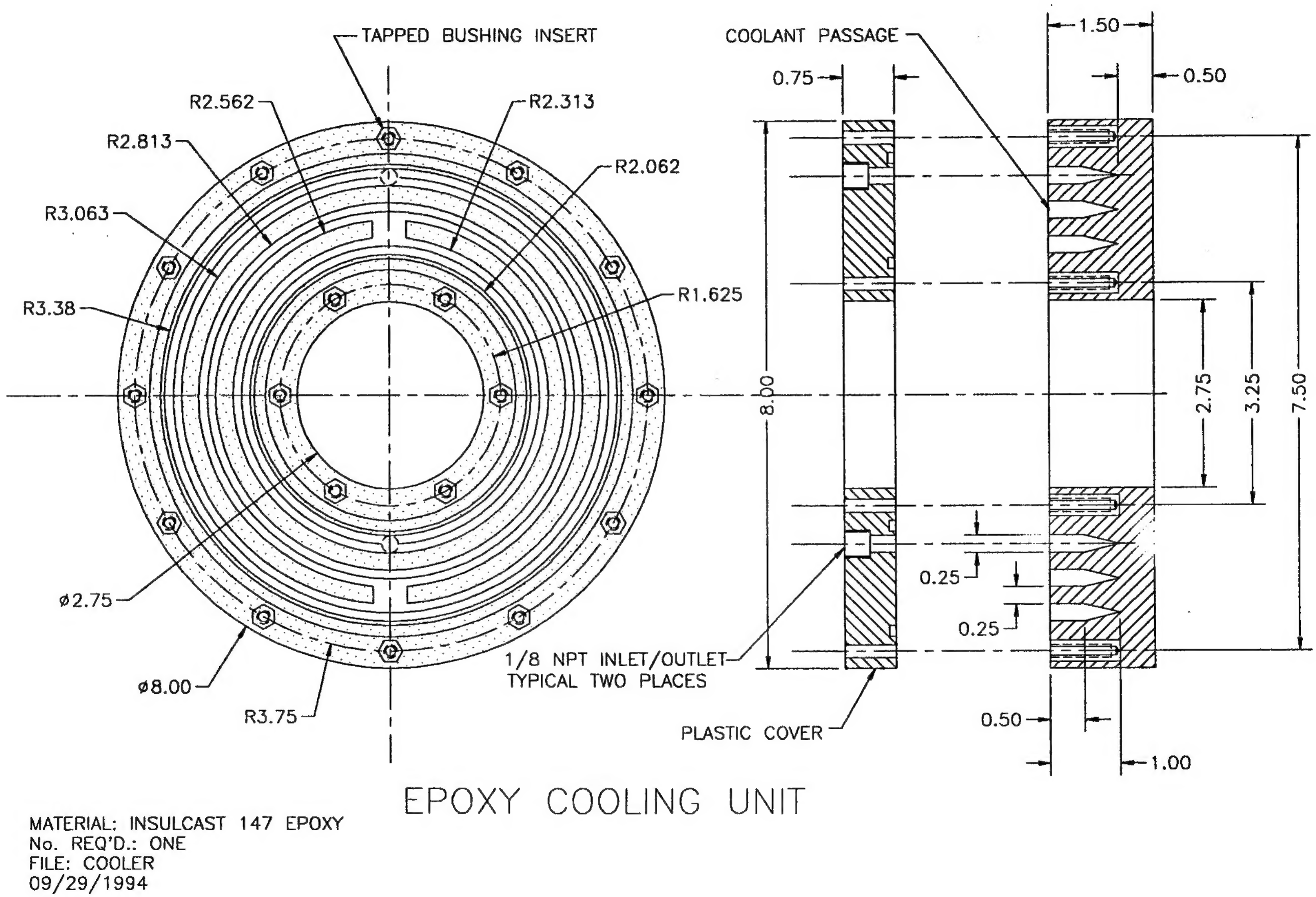
TAPPED BUSHING INSERT
R2.562
R2.313
R2.813
R2.062
R3.063
R3.38
R1.625
ø2.75
ø8.00
R3.75
COOLANT PASSAGE
1.50
0.75
0.50
8.00
2.75
3.25
7.50
0.25
0.25
1/8 NPT INLET/OUTLET
TYPICAL TWO PLACES
PLASTIC COVER
0.50
1.00
EPOXY COOLING UNIT
MATERIAL: INSULCAST 147 EPOXY
No. REQ'D.: ONE
FILE: COOLER
09/29/1994

Figure 1